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Has Canada Specialized in the Wrong Manufacturing Industries?

Ed Wolff
New York University

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Edward N. Wolff

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During the period from 1960 to 1990, there was a remarkable degree of convergence in overall labor productivity between Canada and the United States. According to the data from the Penn World Table (PWT) Mark 5.6 (see Summers and Heston, 1991, for a description of the database), in 1960 Canada's overall labor productivity was 73 percent of the U.S. level and by 1990 it had reached 95 percent (see Wolff, 1997, for details).[1]1 However, since that time, it has retreated relative to the U.S. and by 1995 the productivity ratio between the two countries fell under 90 percent Part of this divergence is due to a resurgence of labor productivity growth in the U.S. but part is also due to continued sluggish productivity growth in Canada. Moreover, as we shall see in Section 1, the pattern is very similar for relative productivity growth within manufacturing.

The main focus of the paper will be to investigate changes in industries of specialization within manufacturing in Canada and examine their implications for the relative slowdown of manufacturing productivity growth within Canada. My primary hypothesis is that Canada may have specialized in the "wrong" industries. In particular, Canada focused on a range of mid-tech

[1] Updates of the data to 1995 were supplied by Robert Summers.

industries such as autos and natural resource intensive sectors, which may have turned out to be the low productivity growth industries of the 1990s.

The period of analysis will be 1970 to 1997. The primary data source is the OECD STAN (Structural Analysis) database, which provides statistics on output and employment for each country and year for 33 manufacturing industries and 14 OECD countries. A secondary source will be the OECD ISDB (International Intersectoral) Database, which provides similar data, as well as gross capital stock, for ten major sectors among the 14 OECD countries. These data will be supplemented by data from the U.S. bureau of Economic Analysis and Statistics Canada. I use Balassa's Revealed Comparative Advantage index to measure specialization. Comparisons of Canada with the U.S. will be featured.

The paper will be organized as follows. Section 1 provides comparative data on Canada's aggregate manufacturing performance for the period 1970-1997 with that of the U.S. Section 2 provides details on patterns of industry specialization for Canada with comparisons with the U.S. over the period 1970-1997. The analysis is performed both among 33 detailed industries within manufacturing. Section 3 presents a similar set of statistics on comparative productivity performance. Section 4 will provide a decomposition of the change in both Canada's and the United States' aggregate manufacturing productivity growth into two effects: the first from the change in the distribution of employment or output among the industries of the manufacturing sector and the second from the change in productivity growth rates of the various industries of the economy. The results of this decomposition can then be used to determine whether Canada's specialization in particular industries and sectors has retarded its overall productivity performance in the 1990s. Conclusions are offered in the last section.

1. <u>Comparisons of Aggregate Performance</u>

Table 1 shows the basic statistics for the entire manufacturing sector from the period 1960 to 1997, based on data from the OECD Intersectoral Data Base (ISDB). Output is measured by GDP in 1990 U.S. dollars, labor by hours worked (employment times average hours per year), and capital by gross non-residential fixed plant and equipment in 1990 U.S. dollars (with individual country service lives). Factor shares used to compute TFP are based on the average ratio of employee compensation to GDP for Canada and the U.S. over the 1970-1997 period.[2]1

Total factor productivity (TFP) here is defined as

$$(1) \quad \text{Ln TFP}^h_t = \text{Ln } Y^h_t - \alpha \text{ Ln } L^h_t - (1 - \alpha)\text{Ln } K^h_t$$

where Y^h is the total output of country h, L^h is its labor input, K^h its capital input, and α is the international (Canada-US) average wage share. TFP growth, R, is then defined as:

$$(2) \quad R^h_t = Y^{*h}_t - \alpha L^{*h}_t - (1 - \alpha) K^{*h}_t$$

where a star (*) indicates the rate of growth. TFP growth is thus equal to the rate of output growth less a weighted sum of the growth rates of labor input and capital input. The actual calculation of TFP growth uses the average wage share over the period of estimation (referred to

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[2] Following the ISDB convention, I measure the wage share as employee compensation in national currency at current prices multiplied by the ratio of total employment (ET) to the number of employees (EE) and then divided by GDP in national currency at current prices.

as the Tornqvist-Divisia approximation).

Panel A shows real output growth in manufacturing in the two countries and highlights the sharp fall-off in output growth in both Canada and the U.S. after 1970. Indeed, in the 1960s, manufacturing GDP was growing at an annual rate of 6.3 percent in real terms in Canada. It fell to 3.4 percent in the 1970s, 2.7 percent in the 1980s, and then to 1.5 percent in the 1989-97 period. Like Canada, real annual output growth in manufacturing in the U.S. declined sharply between the 1960s and 1970s, from 4.5 to 2.3 percent. however, unlike Canada, it recovered to 2.7 percent in the 1980s and 2.6 percent in the 1989-97 period.[3]1 According to these estimates, output growth in Canadian manufacturing exceeded that of the U.S. in both the 1960s and 1970s, was about even in the 1980s, but fell considerably below the U.S. level in the 1990s. Over the entire 1970-97 period, manufacturing output growth was slightly greater in Canada than the U.S.

Data on hours worked (Panel B) shows that labor input growth was considerably higher in

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[3] These and the subsequent figures differ from those reported by Sharpe (1999). Sharpe's data are based on the U.S. Bureau of labor Statistics' (BLS) international comparison of manufacturing productivity, whereas the ISDB data are based on the U.S. Bureau of Economic Analysis' and Statistics Canada's National Income and product Accounts data. The U.S. Bureau of Labor Statistics bases its output measures in manufacturing on material indicators, such as units of automobiles produced, whereas the NIPA output measures are based on double deflated value added. Despite the difference in technique, the BLS data also show a pronounced decline in output growth in Canadian manufacturing between the 1981-89 and 1989-97 periods and almost no change in U.S. manufacturing output between these two period.

Canadian than American manufacturing in the 1970s but about equal in the 1980s (both close to zero) and in the 1989-97 period (both negative). Between 1970 and 1997, hours worked grew at 0.47 percent per year in Canada and virtually zero in the U.S. The growth in gross capital stock in manufacturing was also slightly higher in Canada than the U.S. between 1970 and 1997. In fact, the growth rates in the two countries were very close in the 1960s and 1970s, over a percentage point greater in Canada than the U.S. in the 1980s, but about half a percentage point lower in Canada than the U.S. in the 1989-97 period.

Annual TFP growth in Canada averaged 1.2 percent in 1970-81, rose to 1.6 percent in the 1981-89 period, and then retreated to 1.1 percent in the 1989-97 period (see Panel D). Over the entire 1970-97 period, it averaged 1.3 percent per year. Annual TFP growth in the U.S. was higher over the same period, 1.6 percent. It was 0.3 percentage points lower than Canadian TFP growth during the 1970s and 0.3 percentage points higher in the 1980s, but whereas Canadian TFP growth fell off in the 1989-97 period, American TFP growth rose to 2.2 percent per year. As a result, the gap in TFP performance expanded enormously over this period, reaching 1.0 percentage points in the 1990s.

Also shown in Panel D is the ratio of the Canada's TFP level to the TFP level of the U.S. (also see Figure 1). There was a strong catch-up on the U.S. level between 1970 and 1985, with the ratio rising from 0.81 to 0.89, but this was followed by a precipitous decline to 0.75 in 1997.

The growth in capital intensity (the ratio of gross capital to hours worked) in Canada increased from 2.4 percent per year in the 1970s to 3.3 percent per year in the 1980s, but then declined sharply to 2.0 percent per year in 1989-97 (see Panel E). Over the entire 1970-97 period, it averaged 2.6 percent per year, compared to 2.9 percent per year in the U.S. However, in the U.S., annual capital-labor growth slipped from 3.percent in the 1970s to 2.0 percent in the 1980s before recovering to 2.7 percent in the 1989-97 period. As a result, capital intensity in Canada fell from 90 percent of the U.S. level in 1970 to 78 percent in 1981, then almost reached parity with the U.S. in 1992 (98 percent), before plummeting to 82 percent by 1997.

Labor productivity growth depends on both the rate of technical change (TFP growth) and the growth in capital intensity. The reason can be seen by re-writing equation (2) as:

$$(3) \qquad \Pi^{*h}_t = R^h_t + (1 - \alpha)\, c^{*h}_t$$

where Π = Y/L, the level of aggregate labor productivity, Π^* is the rate of labor productivity growth, c = K/L, the ratio of the capital stock to labor, and c* is the rate of growth of the capital-labor ratio.

Annual labor productivity growth in Canada averaged 2.0 percent in 1970-81, rose to 2.7 percent in the 1981-89 period, due to an acceleration in both TFP growth and the growth in the capital-labor ratio, but then dropped back to only 1.8 percent in the 1989-97 period, due to weakening capital accumulation and a collapse in TFP growth. Over the entire 1970-97 period, it averaged 2.1 percent per year. Labor productivity growth in the U.S. was higher over the same period, 2.5 percent. It ran even with Canadian labor productivity growth during the 1970s and 1980s, but whereas Canadian productivity growth fell off in the 1989-97 period, American productivity growth accelerated to 3.0 percent per year, due to gains in both capital investment and TFP growth. As a result the gap in labor productivity growth widened to 1.2 percentage points in the 1990s.

Also as a consequence, there was a modest catch-up on the U.S. labor productivity level between 1970 and 1979, with the ratio rising from 0.78 to 0.83, a fall off to 0.78 in 1989, another period of gain to 0.83 in 1993, and then a marked decline to 0.71 in 1997.

2. Patterns of Industry Specialization in Manufacturing

In order to understand these time trends and the different paths followed by the U.S. and Canada over the postwar period, I next investigate patterns of specialization for both Canada and the U.S. within the manufacturing sector. I make use of the 1998 OECD STAN database, which covers the time period 1970 to 1996.[4]1 This source provides statistics on value added, measured in both current and 1990 local prices;[5]1 total employment; employee compensation;[6]1 and PPP conversion factors for each country and year.[7]1 Data on each of these variables are provided for 33 manufacturing industries.

Comparisons of output among the countries is made on the basis of value added by industry in 1990 local currency converted to 1990 U.S. dollars on the basis of the 1990 PPP rate for that country. Specialization is measured by the share of the total production of a given commodity made in an individual country relative to its share of GDP:

(4) $$RELPSHR_i^h = [y_i^h / \Sigma_h\, y_i^h] / (GDP^h / \Sigma_h\, GDP^h)$$

where y_i^h is the output of sector i in country h and the GDP figures, obtained from the OECD

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[4] Some series do extend to 1997 for a limited set of countries.

[5] The value added is exclusive of value added taxes and other indirect business taxes.

[6] This is defined as the sum of wages and salaries, social insurance taxes, and other employee fringe benefits paid by the employer.

[7] Unfortunately, PPPs are not available on the industry level.

ISDB, are in 1990 U.S. dollars. This index is analogous to Balassa's Revealed Comparative Advantage (RCA) measure (Balassa 1965), which is used to measure trade specialization. The numerator of RELPSHR indicates country h's share of the total production of industry i, while the denominator measures country h's share of total GDP for these 14 countries. A value above (below) 1 indicates that country h's share of the group's total production of product i is higher (lower) than its share of the total GDP of this group. This index indicates in which product lines a country's production are concentrated, which is taken as a measure of specialization. In general, some values of RELPSHR for a country will be greater than 1, while others will be less than 1.[8]1

The 33 industries selected are the most detailed ones available with the requisite data. They are all three-digit ISIC industries, with the exception of transport equipment, which is available on the four-digit level. These industries are divided into three technology groups on the basis of the average R&D intensity of production of these industries in OECD countries in 1985, as follows: low-tech -- less than 0.5 times the mean R&D intensity; medium-tech -- from 0.5 to 1.5

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[8] I have defined RELPSHR as a country's share of the total output of a particular industry relative to its share of total GDP rather than to its share of total manufacturing output in order to reflect the fact that some countries such as Japan have specialized production in manufacturing relative to non-manufacturing sectors. Countries with a large manufacturing sector will tend to have a large number of industries with values of RELPSHR exceeding one, and conversely.

the mean R&D intensity; and high-tech -- over 1.5 the mean R&D intensity.[9]1

Calculations of RELPSHR for Canada and the U.S. are shown in Table 2. In 1970, Canada accounted for 2.6 percent of total manufactures of this group of 14 countries and the U.S. for 40 percent. Canada's share of total manufacturing was somewhat less than its GDP share (3.2 percent), accounting for a RELPSHR score of 0.81, as was the U.S. manufacturing share (40 versus 45 percent), resulting in a RELPSHR of 0.89. Canada's specialization in manufacturing increased somewhat between 1970 and 1979, from a RELPSHR score of 0.81 to 0.84, but then declined to 0.78 by 1997, though its share of the total manufacturing output of the 14 OECD countries remained virtually unchanged between 1970 and 1997. In contrast, the U.S. specialization in total manufacturing remained virtually constant over the 1970-1997 period, though its share of the total manufacturing output declined by three percentage points over this period.

In 1970, Canada's major comparative advantage was in other transport equipment (a RELPSHR of 4.98). It was also strong in paper and paper products (a RELPSHR of 2.34), non-ferrous metals (RELPSHR of 1.55), beverages (RELPSHR of 1.35), wood products (RELPSHR of 1.35), railroad equipment (RELPSHR of 1.28), and food products (RELPSHR of 1.25). As is evident, Canada's primary manufacturing strength in 1970 lay in transport equipment and natural resource based industries (food, metals, wood, and paper).

Between 1970 and 1997, Canada expanded its specialization in other transport equipment (a RELPSHR score of 6.97 in 1997), railroad equipment (RELPSHR of 2.51), non-ferrous metals

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[9] Also, see Wolff (1999) for more details on the calculation of relative production shares.

(RELPSHR of 1.84), and wood products (RELPSHR of 1.80); but reduced its specialization in paper and paper products (RELPSHR of 1.69). Moreover, it added new strength in motor vehicles (RELPSHR of 1.41), but lost its specialization in food and beverages. However, all in all, Canada retained its specialization in transport equipment and natural resource based industries (metals and wood) -- all low-tech of medium-tech industries.

In contrast, the United States' major specialization in both 1970 and 1997 was aircraft (a RELPSHR value of 1.66 and 1.76, respectively). It was also strong in professional goods (RELPSHR values of 1.20 and 1.34, respectively), and petroleum and coal products (RELPSHR values of 1.10 and 1.27, respectively). The U.S. made its major gains in low-tech industries, such as food, apparel, and wood products; lost share in the medium-tech industries; but retained its share in the high-tech industries.

Panel A of Table 3 shows the correlation and rank correlation between the distribution of relative production shares between the countries. There are, of course, statistical problems using a correlation coefficient between two distributions, since the individual elements in each distribution are not independent. In particular, if one share is high, one or more others must be low, since the sum of productions shares within industry and across countries must equal 1.0. The same is true for the ranking of industries. However, the correlation coefficient and the rank correlation do provide rough measures of the similarity between two distributions.

What is, perhaps, most striking is the low correlation coefficients between Canada and the United States: -0.26 in 1970, -0.33 in 1979, and -0.26 in 1997. This is true despite the close integration of the two North American economies. The rank correlations are negative for 1970 and 1979 but smaller in absolute value (-0.06 and -0.12, respectively) but slightly positive in 1997 (0.09). The fact that the correlations are generally negative (or positive but close to zero) indicates that Canada has specialized its production in distinctly different industries than the U.S. The straight correlation coefficients show no evidence of convergence in industries of specialization between Canada and the United States, though the rank correlation suggest a very mild convergence. Comparisons with Japan and Germany indicate that the Japanese production structure is even more dissimilar to the American than is the Canadian, but the German production structure is slightly closer to that of the United States than is the Canadian.

Panel B shows the correlation over time of relative production shares in each country. Two measures are used: RELPSHR and the logarithm of RELPSHR. One unfortunate property of the RELPSHR measure is that it is both asymmetric and highly skewed, with a range from zero to infinity. As a result, industry production shares greater than average receive greater weight in the computation of the coefficient of variation than those less than average (which range in value from 0.0 to 1.0). The alternative measure, the logarithm of RELPSHR, has a more normal distribution and gives equal weight to below and above average production shares. In the case of Canada, the latter give a lower correlation than the former, because of the very high value of RELPSHR for the other transport equipment industry.

Both measures show considerable stability in Canada's production structure over time. The correlation in Canadian RELPSHR values between 1970 and 1979 is 0.97 and that between 1979 and 1997 is 0.98, compared to American RELPSHR correlations of 0.95 and 0.90, respectively. The correlation coefficients over time are also considerably higher than those of Germany and especially Japan. The correlations in the logarithm of RELPSHR values for Canada are 0.94 for the 1970-1979 period and 0.90 for the 1979-1997 period, compared to U.S. correlations of 0.95 and 0.91, respectively. By this measure, the stability in the Canadian industrial mix is comparable to Germany's but grater than Japan's.

3. Labor Productivity Differences.

I next turn to a comparison of industry labor productivity levels, also on the basis of the STAN database. Let us first define the labor productivity level, LP, of industry i in country h as:

(5) $LP_i^h = y_i^h / n_i^h$

where n_i^h is total employment in industry i of country h. The (weighted) average labor productivity of industry i in the 14 countries is given by:

$$AVELP_i = \Sigma_h \, y_i^h / \Sigma_h \, n_i^h$$

In analogous fashion to RELPSHR, I define

(6) $RELLP_i^h = LP_i^h / AVELP_i$

which shows productivity in industry i of country h relative to the average productivity in industry i of the 14 countries.

In 1970 Canadian labor productivity in total manufacturing was 13 percent greater than the average among OECD countries (see Table 4). In 1979, overall labor productivity in Canada was still 12 percent above the OECD average but by 1997 it had dropped to 7 percent below average. In comparison, U.S. labor productivity in total manufacturing was 47 percent above the OECD average in 1970, 29 percent above average in 1979, and 26 percent above average in 1997. According to these data, the productivity gap between the U.S. and Canada thus widened from 30 percent in 1970 to 35 percent in 1997. Indeed, in 1970, U.S. productivity exceeded Canadian productivity in 22 out of 29 manufacturing industries, including a single transport equipment sector (384) but excluding the 5 transport equipment subsectors (3841-3849). In 1979, that figure had dropped to 21 out of 29 industries but by 1997 the number had climbed to 24 out of 29.

The main strengths of Canadian manufacturing in terms of productivity in 1970 were railroad equipment (66 percent above average), rubber products (59 percent above average), pottery and china (51 percent above average), electrical machinery, beverages, and non-metal products (all at 44 percent above average), and paper and paper products (39 percent above average).

Between 1970 and 1997, Canada increased its productivity advantage in railroad equipment (81 percent above average in 1997) and still retained its advantage in pottery and china (37 percent above average). However, its productivity fell below average in rubber products, electrical machinery, beverages, non-metal products, and paper and paper products. However, it did manage to rise above average in petroleum and coal products (60 percent above average in 1997).

The main productivity strengths of U.S. manufacturing in 1970 were in the medium-tech and high-tech industries, all 50 percent or higher than average. These include industrial chemicals, motor vehicles, other chemicals products (including drugs and medicines), non-electrical machinery (including computers), electrical machinery, professional goods. The United States was also strong in a host of low-tech industries as well -- particularly, shipbuilding (over double the OECD average), tobacco (double the average), wood products (86 percent above average), and iron and steel (69 percent above average).

In 1997, productivity in U.S. manufacturing was still well above average in four high-tech industries -- non-electrical machinery (52 percent above average), professional goods (44 percent above average), other chemical products (43 percent above average), and aircraft (26 percent above average) -- and two medium-tech industries -- railroad equipment (37 percent above average) and industrial chemicals (35 percent above average). It also remained strong in several low-tech industries, including rubber products (46 percent above average), metal products (45 percent above average), textiles (44 percent above average), and wood products (43 percent above average). However, its productivity performance in motor vehicles slipped to the overall OECD average by 1997, and its productivity level in shipbuilding fell below average.

As shown in Table 5, the correlation coefficients and rank correlations in industry RELLP between Canada and the United States are positive but small in 1970, 1979, and 1997. While the correlation coefficient did rise over the period, from 0.24 to 0.37, the rank correlation was about the same in 1997 as in 1970. Correlations in relative productivity levels between Canada and the U.S. were actually a lot stronger than those between Japan and the U.S. or Germany and the U.S, which were generally negative. Still, the results show that Canada and the U.S. differ rather significantly in terms of industries with high and low productivity levels.

Moreover, Canada's strengths in terms of productivity changed markedly over time. The correlation in RELLP values is 0.75 between 1970 and 1979 (0.70 for the correlation in the logarithm of RELLP), 0.30 between 1979 and 1997 (0.44 for the logarithm of RELLP), and only 0.11 between 1970 and 1997 (0.12 for the logarithm). The United States showed more stability, with correlation coefficients of 0.88 (0.88 for the logarithm of RELLP) between 1970 and 1979, 0.61 (0/72) between 1979 and 1997, and 0.55 (0.61) between 1970 and 1997. Indeed, Germany, displayed amazing stability in terms of its productivity strengths (a correlation of 0.97 for RELLP and 0.88 of the logarithm of RELLP between 1970 and 1997). Japan's relative productivity positions also changed substantially over time, though not nearly as much as did Canada's.

Together, this set of results indicates that Canada was strong in different industries than the United States not only in terms of relative production shares but also in terms of productivity performance. Its productivity strengths (and weaknesses), like its relative production shares, also changed significantly over time.

4. Decomposition Analysis.

I next make use of a decomposition analysis to separate out the effects of two factors on aggregate productivity performance. The first is from productivity growth within industry and the second is from the composition of industries (or patterns of specialization) within the country.

A. Labor Productivity Growth. I first consider the growth of overall labor productivity in manufacturing. We can decompose the change in aggregate labor productivity into two effects: the first from the change in the distribution of employment among the sectors of the economy and the second from the change in relative productivity levels of the various sectors of economy. It is straightforward to show that:

$$(7) \qquad \Pi^h = \Sigma_i \, p_i^h \pi_i^h$$

where $\pi_i^h = y_i^h/n_i^h$ is the labor productivity level in industry i in country h and $p_i^h = n_i^h / \Sigma_i n_i^h$ is the share of total employment in industry i of country h. There is no simple decomposition of aggregate labor productivity growth into sectoral labor productivity growth rates, as there is for TFP growth, as seen below.

Table 6 shows the effects of different employment shares p_i on overall labor productivity growth in both Canadian and U.S. manufacturing. The effects of different employment shares on overall labor productivity growth in Canadian manufacturing is very muted (Panel A). During the 1970-81 period, overall labor productivity growth employment averaged 1.97 percent per year. With employment weights of 1989 or 1997, aggregate productivity growth would have been marginally higher, at 2.01 percent per year. Even if Canadian manufacturing had had the same employment composition of U.S. manufacturing over the 1970-81 period, annual labor productivity growth would have increased by only 0.12 percentage points.

For the 1981-89 period, 1981 employment weights would have yielded the highest aggregate labor productivity growth of 2.70 percent per year, only 0.04 percentage points higher than the actual rate of 2.66 percent. In this case, U.S. manufacturing employment weights would have yielded a lower rate of annual productivity growth, 2.49 percent. For the 1989-97 period, the highest rate of labor productivity growth would have occurred if employment weights had remained at their 1970 percentages, 1.94 percent per year compared to the actual rate of 1.80 percent per year. Switching to U.S. employment weights for the 1989-97 period would have increased Canadian aggregate labor productivity growth but by only 0.12 percentage points. Over the entire 1970-97 period, adoption of employment weighs of any of the four years (1970, 1981, 1989, or 1997) or of U.S. employment weights for this period would have made virtually no difference in the aggregate productivity performance of Canadian manufacturing.

The story is quite similar for U.S. manufacturing (see Panel B). In the 1970-81 period, there is almost no variation of aggregate labor productivity growth with employment weights of other years or with Canadian employment weights. For the 1981-89 period, the (United States') 1981 employment weights would have yielded the highest rate of overall labor productivity growth, 2.60 percent per year in comparison to the actual rate of 2.54 percent per year. If U.S. manufacturing had had the same employment composition as Canadian manufacturing over this period, overall productivity growth would have fallen by 0.39 percent per year.

For the 1989-97 period, the highest aggregate productivity growth would have occurred with the 1981 employment weights, 3.23 percent per year compared to the actual rate of 3.03 percent per year. However, adopting Canadian employment weights would have substantially lowered U.S. aggregate annual productivity growth, by 0.59 percentage points. Over the whole 1970-97 period, as in the Canadian case, overall labor productivity growth is virtually invariant with respect to the employment weights of different years. However, the overall annual rate would have dropped by 0.27 percentage points if U.S. manufacturing had had the same average employment shares as Canadian manufacturing over this period.

B. TFP Growth. Table 7 shows the effects of changing output composition on aggregate TFP growth. Here an exact decomposition is possible. First define:

(8) $\beta_i^h = p_i^h y_i^h / \Sigma_i \, p_i^h y_i^h$

where β_i^h shows the share of industry i's output (in national currencies at current prices) in the total output of country h. For this application, I will look at only total manufacturing. It follows directly that:

(9) $R^h = \Sigma_i \, \beta_i^h r_t^h$

where r_i^h = is TFP growth in industry i in country h and β_i^h is, as before, the output share of industry i in country h in current prices.

Table 7 shows results for the case when output shares β_i are fixed over time. The results differ from the those for labor productivity (in Table 6). For Canada, shifts in output composition over time would have had very little effect on overall TFP growth in the 1970-81 and 1981-89 periods but appears to have lowered it in the 1989-97 period. In the later period, annual TFP growth would have been 0.16 percentage points higher with 1970 output weights than with the actual output composition of the period. However, over the whole 1970-97 period, there is very little variation in aggregate TFP growth with different Canadian output weights.

The biggest difference is from comparing U.S. to Canadian output composition. Adopting U.S. output composition would have substantially improved Canadian productivity performance. Annual aggregate TFP growth would have risen by 0.32 percentage points on the 1970-81 period, by 0.33 percentage points in the 1981-89 period, by 0.08 percentage points in the 1989-97 period, and by 0.25 percentage points over the entire 27-year time span.

In the case of the United States, there is very little variation in overall manufacturing TFP growth in the 1970-81 period with respect to the output weights of different years or with respect to Canadian output weights of that year. For the 1981-89 period, aggregate annual TFP growth, which averaged 1.90 percent, would have increased by at most 0.07 percentage points, with 1997 weights, but would have been a full 0.2 percentage points lower if output shares had remained at their 1970 composition. With Canadian output shares, U.S. TFP growth would have fallen substantially, by 0.45 percentage points.

For the 1989-97 period, different output shares would have made a marked difference in overall TFP growth. The lowest annual rate would have occurred with the output shares of 1989, a drop of 0.17 percentage points, but 1981 output composition would have raised it by 0.25 percentage points and the 1997 shares by 0.18 percentage points. If output composition had been the same as in Canada over this period, overall U.S. TFP growth would have again declined substantially, by 0.64 percentage points per annum. Over the entire 27-year period, when annual TFP growth averaged 1.57 percent, the highest rate would have occurred with 1981 weights, 1.64 percent, and the lowest rate with 1970 shares, 1.50 percent. Adopting Canadian output weights over this period would have caused a 0.33 percentage point reduction in overall annual TFP growth.

5. Conclusion

Annual labor productivity growth in Canadian manufacturing increased from 2.0 percent in 1970-81 to 2.7 percent in the 1981-89 period, but then declined to 1.8 percent in the 1989-97 period. American labor productivity growth in manufacturing was about the same as Canadian labor productivity growth during the 1970s and 1980s but jumped to 3.0 percent per year in the 1989-97 period, causing a gap of 1.2 percentage points in labor productivity performance in the 1990s. Also as a result, there was a modest catch-up on the U.S. labor productivity level between 1970 and 1993, with the ratio rising from 0.78 to 0.83, and then a marked fall-off to 0.71 in 1997.

Annual TFP growth in Canada's manufacturing sector rose from 1.2 percent in 1970-81 to 1.6 percent in the 1981-89 period but then dropped to 1.1 percent in the 1989-97 period. Annual TFP growth in the U.S. was somewhat lower than Canadian TFP growth during the 1970s and somewhat higher in the 1980s, but whereas Canadian TFP growth fell off in the 1989-97 period, American TFP growth rose to 2.2 percent per year. As a result, the gap in TFP performance reached 1.0 percentage points in the 1990s. Moreover, the ratio of Canada's TFP level to the U.S. level increased from 0.81 in 1970 to 0.89 in 1985 but then collapsed to 0.75 in 1997.

Canada and the U.S. tend to specialize their manufacturing production in different industries. Canada is strong in transport equipment, particularly railroad equipment and motor vehicles, non-ferrous metals, and wood products. The United States has a more diversified industrial structure but has a relatively high concentration in aircraft, professional goods, and petroleum and coal products. Moreover, despite the close integration of the two North American economies, the correlation coefficients in relative production shares between Canada and the United States are all negative or close to zero. There is also little evidence of convergence in industries of specialization between Canada and the United States over time. Indeed, both countries show considerable stability in production structure over time.

The main purpose of the paper is to examine the effects of industrial structure on productivity performance. In the case of Canada, changing (domestic) employment weights over time had little effect on aggregate labor productivity growth, except for the 1989-97 period. In that case, switching back to the 1970 employment weights would have led to 0.16 percentage point gain in productivity growth. Shifting to U.S. composition would also have had virtually no effect on aggregate Canadian productivity growth over the entire 1970-97 period. For the 1989-97 period, it would have increased aggregate labor productivity growth by 0.12 percentage points, not enough to offset the pronounced slowdown.

However, changes in output composition do have a potentially significant effect on Canadian TFP performance. There is evidence that Canadian manufacturing has been moving toward industries with relatively low productivity growth rates. In particular, shifting back to the 1970 output weights would have led to a 0.16 percentage point gain in aggregate annual TFP growth in the 1989-97 period. Moreover, adoption of U.S. output weights would have increased annual TFP growth by 0.32 percentage points on the 1970-81 period, 0.33 percentage points in the 1981-89 period, by 0.08 percentage points in the 1989-97 period, and by 0.25 percentage points over the entire 27-year time span. This, again, would not have been enough to offset the slowdown in TFP growth in the 1990s.

In the U.S. case, there is no evidence that shifting employment weights over time had much effect on overall labor productivity growth but the results do indicate that output shifted over time towards sectors with higher TFP growth, at least during the 1980s and 1990s. The U.S. also appears significantly better off with its own employment and output weights than the corresponding Canadian ones. Canadian employment weights would have resulted in a substantial decline in overall annual labor productivity growth of 0.59 percentage points in the 1989-97 period and 0.27 points in the full 1970-97 period. Likewise, adopting Canadian output weights of the period would have caused overall annual TFP growth to decline by 0.45 percentage points in the 1981-89 period, 0.64 percentage points in the 1989-97 period, and 0.33 percentage points over the entire 1970-97 period.

The slowdown in productivity growth experienced by Canada in the 1990s is primarily due to declines in productivity growth on the industry level, not to shifts in employment or output composition. However, the evidence does suggest that over the whole 1970-97 period, Canada would have been better off moving more toward a U.S. industrial structure, particularly high-tech industries. The slowdown itself might not have been avoided but overall TFP growth might have been raised by 0.2 to 0.3 percentage points over the 27 years.

On a final note, it might seem paradoxical that adopting other country's output weights would not have had more effect on productivity growth, particularly since the U.S. and Canada specialize in such different industries. The reason is that the specialization (Balassa) index is based on a country's output share **relative** to the overall OECD average share. In point of fact, the actual shares themselves vary much less across countries than relative production shares.

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Table 1
Average Annual Growth in TFP, Labor Productivity, and the Capital-Labor Ratio, In Total Manufacturing for Canada and the United States, 1970-97[a]

(figures are in percent per annum)

	1960-1970	1970-1981	1981-1989	1989-1997	1997	1970-1997
A. GDP Growth						
Canada	6.31	3.36	2.67	1.48		2.60
U.S.A	4.49	2.29	2.66	2.56		2.48
B. Growth in Total Hours Worked						
Canada	--	1.39	0.01	-0.32		0.47
U.S.A.	1.43	0.21	0.12	-0.47		-0.02
C. Growth in Gross Capital Stock						
Canada	4.39	3.81	3.35	1.75		3.06
U.S.A.	4.25	3.95	2.13	2.20		2.89
D. TFP Growth						
Canada	--	1.20	1.60	1.14		1.30
U.S.A	2.15	0.88	1.90	2.17		1.57
Canada/US Level Ratio, beginning of the period		0.81	0.84	0.82	0.75	
E. Growth of the Ratio of Capital to Hours						
Canada	--	2.43	3.34	2.07		2.59
U.S.A	2.82	3.74	2.01	2.67		2.91
Canada/US Level Ratio, beginning of the period		0.90	0.78	0.87	0.82	
F. Labor Productivity (GDP/Hours) Growth						
Canada	--	1.97	2.66	1.80		2.13
U.S.A	3.05	2.08	2.54	3.03		2.50
Canada/US Level Ratio, beginning of the period		0.78	0.77	0.78	0.71	

a. The data source is the OECD Intersectoral Data Base (ISDB), 1997 version. Output is measured by GDP in 1990 U.S. dollars, labor by hours worked (employment times average hours per year), and capital by gross non-residential fixed plant and equipment in 1990 U.S. dollars (with individual country service lives). Factor shares used to compute TFP are based on the average ratio of employee compensation to GDP for Canada and the U.S. over the 1970-1997 period.

Table 2
Relative Production Shares (RELPSHR) in Canada and the United States, 1970, 1979, and 1997[a]

ISIC Code	Industry	Canada 1970	Canada 1979	Canada 1997	United States 1970	United States 1979	United States 1997
3000	Total Manufacturing	0.81	0.84	0.78	0.89	0.90	0.89
Low-Tech Industries							
311.2	Food	1.25	1.06	0.92	0.67	0.69	0.78
313	Beverages	1.35	1.27	1.10	0.44	0.51	0.61
314	Tobacco	0.71	0.64	0.59	1.12	1.13	0.70
321	Textiles	0.39	0.54	0.54	0.63	0.69	0.86
322	Wearing Apparel	1.03	1.27	1.12	0.81	0.82	0.97
323	Leather & Products	0.50	0.59	0.37	0.48	0.51	0.48
324	Footwear	0.45	0.60	0.55	0.74	0.51	0.39
331	Wood Products	1.35	1.58	1.80	1.08	1.11	1.23
332	Furniture & Fixtures	0.72	0.73	0.82	0.71	0.67	0.82
341	Paper & Products	2.34	2.19	1.69	1.06	1.05	1.09
342	Printing & Publishing	0.80	1.00	0.86	1.01	1.11	0.98
353	Petroleum Refineries	0.77	0.73	0.83	0.67	0.60	0.60
354	Petroleum & Coal Prod.	0.21	0.35	0.76	1.10	1.19	1.27
355	Rubber Products	1.01	1.08	0.94	0.94	0.92	0.95
356	Plastic Products, nec	0.48	0.61	0.61	0.74	0.86	0.92
361	Pottery, China, etc.	0.46	0.36	0.23	0.26	0.30	0.28
362	Glass & Products	0.60	0.68	0.54	0.91	0.92	0.75
369	Non-Metal Products,nec	0.78	0.92	0.59	0.65	0.72	0.69
371	Iron & Steel	0.75	0.74	0.91	1.00	0.84	0.72
372	Non-Ferrous Metals	1.55	1.10	1.84	1.01	0.87	0.70
381	Metal Products	0.66	0.69	0.58	0.85	0.95	0.89
3841	Shipbuilding & Repair	0.33	0.52	0.60	0.77	0.71	0.71
39	Other Manufactures nes	1.06	1.11	0.85	0.87	0.63	0.71
Medium-Tech Industries							
351	Industrial Chemicals	0.34	0.38	0.48	0.84	0.85	0.88
3842	Railroad Equipment	1.28	1.92	2.51	0.44	0.39	0.49
3843	Motor Vehicles	0.90	1.13	1.41	0.85	0.87	0.76
3844	Motorcycles & Bicycles	NA	NA	NA	0.35	0.28	0.30
3849	Other Transport Equip	4.98	6.40	6.97	NA	NA	NA
High-Tech Industries							
352	Other Chemical Prod.[b]	0.85	0.96	0.81	1.09	1.06	1.03
382	Non-Electrical Mach.[c]	0.39	0.49	0.56	0.86	0.93	1.09
383	Electrical Machinery[d]	0.72	0.57	0.37	1.11	1.02	0.74
3845	Aircraft	0.38	0.62	0.71	1.66	1.61	1.76
385	Professional Goods[e]	NA	NA	NA	1.20	1.23	1.34

a. The data source is the OECD STAN (Structural Analysis) database. The relative production share of country h in industry i is defined as:

$$RELPSHR_i^h = [Y_i^h \;/\; \Sigma_h \, Y_i^h] \;/\; (GDP^h \;/\; \Sigma_h \, GDP^h).$$

where the aggregation over h is based on 14 OECD countries with pertinent data: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom, and the United States. The exception are industries 3841-3849, which exclude Belgium.

The Division of industries into technology groups is based on the average R&D intensity of production of OECD countries in 1985, as follows: low-tech -

- less than 0.5 times the mean R&D intensity; medium-tech -- from 0.5 to 1.5 the mean R&D intensity; and high-tech -- over 1.5 the mean R&D intensity.

b. Includes Drugs and Medicines and Other Chemicals, nec.

c. Includes Office and Computing Machinery and Machinery & Equipment, nec.

d. Includes Radio, TV & Communication Equipment and Electrical Apparatus, nec.

e. Includes Scientific Instruments.

Table 3

Correlations between Canada and the United States and over Time
In Relative Production Shares (RELPSHR), 1970-1997[a]

A. Correlations between Countries in RELPSHR

	Correlation Coeffs.			Rank Correlations		
	1970	1979	1997	1970	1979	1997
Canada and U.S.A.	-0.26	-0.33	-0.26	-0.06	-0.12	0.09
Memo:						
Japan and U.S.A.	-0.57	-0.50	-0.42	-0.49	-0.42	-0.28
Germany and U.S.A.	0.07	0.13	-0.06	0.17	0.24	-0.01

B. Correlations over Time

	RELPSHR			LN(RELPSHR)		
Country	1970-1979	1979-1997	1970-1997	1970-1979	1979-1997	1970-1997
Canada	0.97	0.98	0.94	0.94	0.90	0.80
United States	0.95	0.90	0.82	0.95	0.91	0.83
Memo:						
Japan	0.84	0.84	0.58	0.88	0.92	0.71
Germany	0.96	0.87	0.76	0.96	0.92	0.82

a. See equation (4) for the definition of RELPSHR. Correlations are based on 33 industries, including 5 transport equipment subsectors, as shown in Table 2, with the following exceptions:

(1) Canada and USA: excludes industry 385.
(2) Canada over time: excludes 3844 and 385.
(3) USA over time: excludes 3849.

Table 4
Relative Productivity Levels (RELLP) in Canada and the United States, 1970, 1979, and 1997[a]

	Canada			United States		
Industry	1970	1979	1997	1970	1979	1997
Total Manufacturing	1.13	1.12	0.93	1.47	1.29	1.26
Low-Tech Industries						
Food	1.22	1.11	0.94	1.15	1.18	1.33
Beverages	1.44	1.19	0.97	0.87	0.94	1.15
Tobacco	0.69	0.66	0.64	2.00	1.94	1.06
Textiles	0.98	1.29	1.02	1.46	1.32	1.44
Wearing Apparel	1.02	1.23	1.08	1.11	1.03	1.10
Leather & Products	0.71	0.88	0.72	1.00	0.95	0.99
Footwear	0.53	0.74	0.95	1.27	0.99	1.13
Wood Products	1.26	1.08	1.11	1.86	1.56	1.43
Furniture & Fixtures	0.91	0.98	0.96	1.04	0.91	0.98
Paper & Products	1.39	1.26	0.97	1.54	1.37	1.36
Printing & Publishing	0.91	1.12	0.94	1.32	1.31	1.05
Petroleum Refineries	0.49	0.43	0.51	0.76	0.64	0.68
Petroleum & Coal Prod.	0.33	0.96	1.60	1.28	1.06	1.09
Rubber Products	1.59	1.35	0.98	1.56	1.29	1.46
Plastic Products, nec	0.94	1.09	1.03	1.34	1.15	1.18
Pottery, China, etc.	1.51	1.11	1.37	1.27	1.20	1.12
Glass & Products	1.04	1.27	0.91	1.47	1.28	1.21
Non-Metal Products,nec	1.44	1.51	0.90	1.33	1.23	1.16
Iron & Steel	1.29	1.08	1.03	1.69	1.26	1.35
Non-Ferrous Metals	0.93	0.69	1.04	1.46	1.14	0.96
Metal Products	1.20	1.14	0.95	1.48	1.45	1.45
Shipbuilding & Repair	0.77	0.94	0.69	2.05	1.14	0.92
Other Manufactures nes	0.86	0.88	0.44	1.20	0.77	0.83
Medium-Tech Industries						
Industrial Chemicals	0.79	0.83	1.09	1.52	1.35	1.35
Railroad Equipment	1.66	1.78	1.81	NA	0.69	1.37
Motor Vehicles	0.98	1.22	1.19	1.51	1.49	1.00
Motorcycles & Bicycles	NA	NA	NA	NA	1.00	0.94
Other Transport Equip	0.65	2.29	1.46	NA	NA	NA
High-Tech Industries						
Other Chemical Prod.	0.98	1.09	0.84	1.53	1.58	1.43
Non-Electrical Mach.	0.75	0.89	0.95	1.47	1.27	1.52
Electrical Machinery	1.44	1.30	0.80	1.84	1.47	1.13
Aircraft	0.73	0.76	0.59	NA	1.15	1.26
Professional Goods	NA	NA	NA	1.59	1.34	1.44

a. Relative labor productivity of industry i in country h defined as:

$$RELLP_i^h = LP_i^h / AVELP_i$$

where the calculation of $AVELP_i$ is based on 14 OECD countries with pertinent data: Australia (AUS), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (GER), Italy (ITA), Japan (JPN), the Netherlands (NET), Norway (NOR), Sweden (SWE), the United Kingdom (UK), and the United States (USA). The exceptions are as follows:

(1) DEN, NET: 1996 data used for 1997 in all industries except total manufacturing (1992 data used)

(3) GER: 1996 data used for 1997 in Chemicals (351-356)

(4) SWE: 1996 data used for 1997 in Industries 353 and 354
(5) Industries 3841 to 3849:
  (a) BEL: missing data for all years.
  (b) FRA, ITA: missing data for 1970
  (c) AUS: 3842, 3845, 3849: missing data for 1970, 1979.
  (d) GER: 3842, 3843, 3844, 3849: missing data for 1970
  (e) JPN: 3842, 3844, 3845, 3849: missing data for 1970, 1979
  (f) UK: 3842, 3844, 3845, 3849: missing data for 1970
  (g) US: 3842, 3844, 3845: missing data for 1970
  (h) DNK: 3841, 3842, 3844: missing data for 1994-1997.

See footnotes to Table 2 for other technical details on the sectoring.

Table 5

Correlations between Canada and the United States and over Time In Relative Labor Productivity (RELLP), 1970-1997[a]

A. Correlations between Countries in RELLP

	Correlation Coeffs.			Rank Correlations		
	1970	1979	1997	1970	1979	1997
Canada and U.S.A.	0.24	0.27	0.37	0.28	0.32	0.27
Memo:						
Japan and U.S.A.	-0.54	-0.32	-0.36	-0.53	-0.38	-0.35
Germany and U.S.A.	0.10	-0.15	-0.22	0.14	-0.26	0.16

B. Correlations over Time

	RELLP			LN(RELLP)		
Country	1970-1979	1979-1997	1970-1997	1970-1979	1979-1997	1970-1997
Canada	0.75	0.30	0.11	0.70	0.44	0.12
United States	0.88	0.61	0.55	0.88	0.72	0.61
Memo						
Japan	0.74	0.72	0.48	0.72	0.79	0.44
Germany	1.00	0.98	0.97	0.96	0.93	0.88

a. See equation (6) for the definition of RELLP. Correlations are based on 29 industries, including a single transport equipment sector (384) but excluding the 5 transport equipment subsectors (3841-3849), unless otherwise noted.

(1) Canada and USA: excludes industry 385.
(2) Canada over time: excludes industry 385.

Table 6

The Effect of Employment Shares on Manufacturing Labor Productivity Growth In Canada and the United States, 1970-1997[a]

(Figures show the rate of labor productivity growth in percent per annum)

Country and Employment Weights	Period 1970-81	1981-89	1989-97	1970-97
A. Canada				
Actual Lab. Prod. Growth	1.97	2.66	1.80	2.13
(1) 1970 Employment (p) Weights	1.99	2.69	1.94	2.14
(2) 1981 Employment (p) Weights	1.95	2.70	1.90	2.12
(3) 1989 Employment (p) Weights	2.01	2.63	1.81	2.10
(4) 1997 Employment (p) Weights	2.01	2.67	1.79	2.11
(5) U.S.A. Employment (p) Weights[b]	2.09	2.49	1.92	2.14
B. U.S.A.				
Actual Lab. Prod. Growth	2.08	2.54	3.03	2.50
(1) 1970 Employment (p) Weights	2.09	2.48	3.16	2.52
(2) 1981 Employment (p) Weights	2.06	2.60	3.23	2.56
(3) 1989 Employment (p) Weights	2.04	2.49	3.03	2.46
(4) 1997 Employment (p) Weights	2.09	2.48	3.03	2.48
(5) Canada Employment (p) Weights[b]	2.10	2.15	2.44	2.23

a. The analysis, derived from equation (7), is based on actual labor productivity growth rates by industry and assumes that employment shares are fixed over the period. The computations are based on 33 industries, including the 5 transport equipment subsectors, for Canada, and on 29 industries, including a single transport equipment sector but excluding the 5 transport equipment subsectors for the United States and for the U.S. weights in Panel A. The data source is the STAN database.

b. Average employment weights over the same time period.

Table 7
The Effects of Output Composition on TFP Growth in Total Manufacturing In Canada and the United States, 1970-1997[a]

(Figures show the rate of TFP growth in percent per annum)

Country and Output Weights	Period 1970-81	1981-89	1989-97	1970-97
A. Canada				
Actual TFP Growth	1.20	1.60	1.14	1.30
(1) 1970 Output (ß) Weights	1.20	1.54	1.30	1.29
(2) 1981 Output (ß) Weights	1.19	1.55	1.20	1.26
(3) 1989 Output (ß) Weights	1.25	1.65	1.16	1.30
(4) 1997 Output (ß) Weights	1.27	1.67	1.12	1.30
(5) U.S.A. Output (ß) Weights[b]	1.52	1.93	1.22	1.55
B. U.S.A.				
Actual TFP Growth	0.88	1.90	2.17	1.57
(1) 1970 Output (ß) Weights	0.88	1.70	2.18	1.50
(2) 1981 Output (ß) Weights	0.88	1.94	2.42	1.64
(3) 1989 Output (ß) Weights	0.79	1.86	2.00	1.46
(4) 1997 Output (ß) Weights	0.89	1.97	2.35	1.63
(5) Canada Output (ß) Weights[b]	0.86	1.45	1.53	1.24

a. The analysis, derived from equation (9), is based on actual TFP growth rates by industry and assumes that output shares are fixed over the period. The computations are based on 13 industries for Canada in the 1970-81 period, 20 2-digit SIC industries for Canada in the 1981-1997 period, and 20 2-digit SIC industries for the United States over the 1970-97 period. The data sources for the Canadian data are the STAN and ISDB databases; the source for the United States data is the National Income and Product Accounts

b Average output weights over time period.

Figure 1. Canada/USA Relative Productivity Ratios
And Relative Capital-Labor Ratios, 1970-1997